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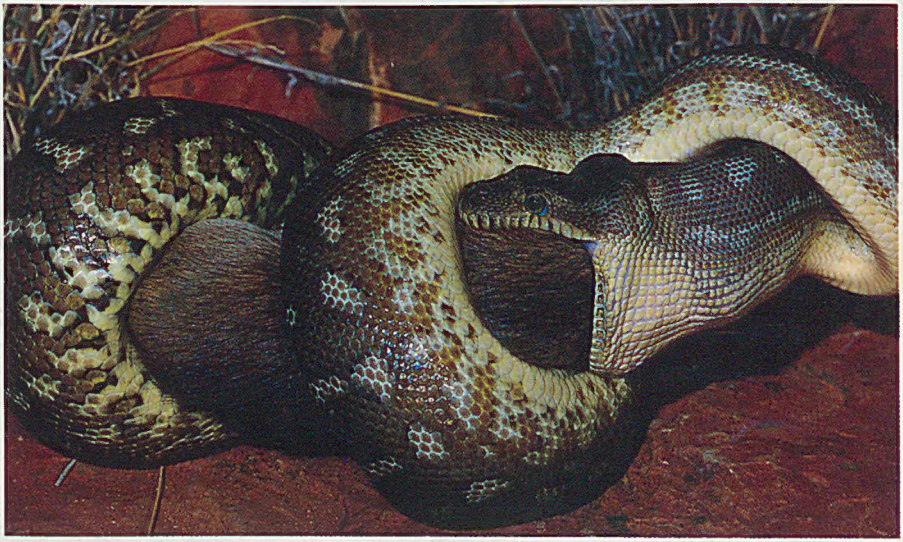

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NOTES ON THE CAPTIVE MAINTENANCE AND BREEDING OF THE SUPERB DRAGON *DIPORIPHORA SUPERBA (AGAMIDAE)*

by John Weigel,
Australian Reptile Park,
Gosford, NSW 2250.

INTRODUCTION

First described in 1974, the Superb Dragon is confined to rocky areas within the Kimberley district of Australia's tropical northwest. It has a small, elongate body (up to 95mm) and a ridiculously long and narrow tail approximately four times the length of the body. The digits are also very long, contributing to the bizarre "stick figure" appearance of the species. Its protracted body form and vivid lime-green colouration serve to camouflage it well among the similarly shaped and coloured leaves of the wattle *(Acacia delibrata)* within the foliage of which it spends considerable time. This tree grows to an average height of only 2-3m and like *D. superba*, appears to be confined to the sandstone formations of the Kimberley district.

A sexual pair of Superb Dragons were collected in January 1987, on behalf of the Australian Museum. It was considered that much could be learned from captive observations of the species, and that the pair could be housed at the Australian Reptile Park until death, at which time they would be lodged at the museum.

OBSERVATIONS IN THE WILD AND COLLECTION OF SPECIMENS

So effective are the cryptic form and habits of this species, that the only productive means of collecting the Superb Dragon appears to be in the shaking of suitable trees in the hope that should a dragon be present, it might fall to the ground. After numerous extended trips into areas where this species occurs, I have seen only a dozen or so specimens. One of these was only detected because it bit my finger when I inadvertently included its tail with a leafy branch I intended to shake. I have seen neither hatchlings or very small specimens nor heard of any reports of these being found.

When captured, both male and female were considered to be sexually mature (75mm and 80mm snout to vent length respectively). Adult Superb Dragons are easily sexed as the presence of hemipenes creates a visible bulge at the base of the male's tail.

HOUSING

From the beginning, the general health and appearance of the Superb Dragons housed at the Reptile Park has been excellent. The display case is 1.8m tall and 1m deep. Three small wattle trees *Acacia longiforum* grow from pots sunk into holes in the cage floor. The leaves of this species are larger, but similar in shape to those of *Acacia delibrata.* On one edge of the exhibit is a sandstone arrangement that includes a crevice, which the lizards don't seem to use. The cage substrate is pale sand with wattle leaf litter. A small bowl of water is maintained at all times. The plants are occasionally alternated with fresh specimens, as they tend to decline in health after a month or so. The inclusion of a fluorescent light fixture fitted with a 20 watt "black light" tube provides low frequency ultra-violet light. These tubes are manufactured under a variety of brand names for use in electric insect traps. We have found that the provision of ultra-violet light, either by sunlight or artificially, is an essential requirement for all agamid lizard species that we have maintained. Heat for the Superb Dragons comes primarily from red coloured reflector lamps directed onto the plants, thereby providing warm "basking" positions. These lamps are on almost continuously, while the ultra-violet tube is turned off at night to allow a day/night cycle.

The exhibit graphics are titled, "Can you see me?", and explain why the dragons are so hard to see and how to go about recognising them within the exhibit. The exhibit generates considerable entertainment with many adults and children when they challenge one another to discern the lizards' elusive forms.

BEHAVIOUR AND FEEDING

For the most part, both the male and female exhibit similar behaviour, though the male appears to be the dominant of the two; the female quickly moving to another of the three plants upon the approach of the male. Usually the lizards can be found resting motionless amongst the wattle branches, sometimes dropping to the ground for a short time. The most active period appears to be at dusk and very early in the morning, when movement from branch to branch, as well as over the cage, takes place. Skin colouration darkens somewhat at night, resuming the brilliant lime hue shortly after the ultra-violet light is turned on in the morning. I have yet to see any specimen drink from the water bowl, but the plants are sprayed with a water mister each morning, and the dragons usually respond by licking droplets from the leaves.

Food is provided daily or at least every second day. Tiny locusts in the second and third instars (1-1.5cm) provide the greatest portion of the dragons' diet in captivity, though this is supplemented with mealworms (both the small larvae and beetles) and ants. All food is offered on forceps and is occasionally coated with a vitamin D and calcium powder mix. The only recognisable remains that I have discerned from the faeces of wild specimens were ants and small beetles.

BREEDING

Although no mating had been observed, the female was visibly gravid by November 1988. As the eggs developed in the following weeks her previously gracile form became enormously distended. A small bird nesting box with a single access hole was provided which was half filled with damp vermiculite. We have found that in most cases, egg laying lizards and snakes will choose to deposit their egg clutches within these nesting boxes when provided. Additionally the cage substrate was kept moist so that any eggs deposited on or beneath the sand would not dry out before being retrieved. On the morning of the 6th December the female was observed to have lost her gravid condition and a search revealed five small eggs within an excavated chamber in the substrate sand. The nest was only a few centimetres deep as the wooden cage floor prevented deeper excavation. The eggs, which had a mean measurement of 9mm x 14.5mm and a mean weight of .6gm, were pale reddish in colour and appeared to be lacking the leathery white shell typical of other lizard eggs produced at the Reptile Park. Our immediate concern upon discovering these unusual eggs was that the female had suffered from a shortage of calcium and had been unable to properly shell the eggs. Fortunately, this proved not to be the case.

EGG INCUBATION AND HATCHING

The Superb Dragon eggs were incubated in the same fashion as most lizard and snake eggs produced at the Reptile Park. They were placed in a 4 litre container half filled with a mixture of heat dried vermiculite and water (3:2 by weight). The eggs were placed just beneath the surface of the incubating medium with their tops barely protruding. The container was sealed with a single layer of transparent plastic food wrap and placed in a dark incubator set at a temperature of 28°C. The plastic allows visibility, and while trapping moisture within, allows at least some movement of gases in and out of the container.

During the first three weeks of incubation the eggs swelled considerably and gradually developed a white, presumably calcified leathery egg surface. The first sign of hatching was a fully emerged neonate within the incubating container on the 23rd of January 1989, 48 days after being deposited. Upon inspection a second individual had managed to slit its egg shell

and extend its head outwards (see Figure 1). None of the other three eggs showed any sign of pipping. By the following morning the second little dragon had completely left its egg, but the other three had yet to show signs of life. That evening a single incision, approximately 4mm in length, was made at the top of each of the remaining eggs as it was feared that the lizards within might have been unable to do so. At this time, the opportunity was taken to measure and weigh one of these remaining eggs as a comparison to its condition at oviposition. It had swollen from its original dimensions of 9mm x 14.5mm to 11mm x 21mm, and from an initial weight of .6gm to 1.1gm. The morning of the 25th January revealed two new hatchlings, but no signs of life from the final egg. This was opened on the morning of the 26th only to find a dead, but fully formed specimen. The four hatchlings had a mean body length of 26mm and a tail length of 55mm. The mean body weight was .7gm. Unlike the lime-green parents, all of the young were a light coppery-brown colour upon hatching, although when placed upon green foliage they quickly took on a very light green colouration. The young appear to change colour depending upon the background, returning to a light brown colouration when upon the similarly coloured sand which covers the cage floor.

CARE OF HATCHLINGS

The hatchlings fed voraciously on small insects, including very small mealworms, hatchling locusts approximately 2mm in length, and similarly sizes ants. For the first three months the young were maintained together in an off exhibit cage measuring 1m x .5m x .5m. Heating and lighting was similar to those provided for the parents. Instead of live plants, small freshly cut wattle branches were included and replaced every few days. The young were invariably found perched in these in close proximity to the ultra-violet light source. These branches were sprayed twice daily with a water mister, the accumulated droplets being licked up by the young dragons.

CONCLUSIONS

A sexual pair of Superb Dragons have been maintained at the Australian Reptile Park since being captured in January 1987. Increased public awareness of the species was generated with a nationally televised news story about the successful breeding of the pair. Numerous public enquiries to the television station resulted in a follow up story on the progress of the young dragons two weeks later - a degree of interest typically reserved for the mammals and birds.

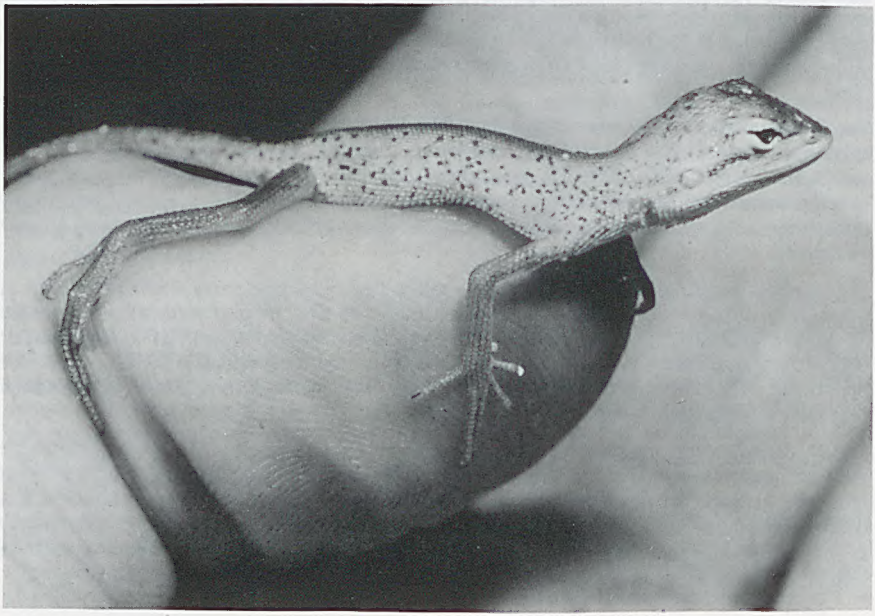
The Superb Dragon colony maintained at the Park has had mixed fortunes. With the successful rearing of three of the captive bred individuals, the original male and female both died inexplicably during 1990. Thorough autopsies failed to determine the cause of the losses. The only male amongst the three young specimens also died in a cage accident in 1990 and though one of the young females laid eggs on the 17th December 1989, these soon deteriorated under incubation.

The remarkable growth of the eggs of *D. superba* from their tiny, thinly shelled condition at oviposition, to their final dimensions and approximately doubled weights implies that the female is able to practically double her productive effort by depositing her eggs in an undeveloped or compacted condition. It would seem that the eggs, which must certainly be deposited in a hypertonic state, contain calcium in some form within, which is deposited to form an outer shell only after sufficient water intake has swollen the egg to its final dimensions.

The Superb Dragons maintained at the Australian Reptile Park proved to be a favourite for staff and visitors alike. The first ever breeding for the species has created a special interest amongst staff who are now keen to experiment with other poorly known agamid species. It is believed that the educational value extended to the visiting public and the zoological community in such instances more than justifies the collection of a small number of specimens from the wild in all but the most severely declined species.

Figure 1. *Diporiphora superba* hatchlings emerging from eggs.

Figure 2. Hatchling *D.superba.*



CAPTIVE BREEDING OF BLACK- HEADED PYTHONS *(ASPIDITES MELANOCEPHALUS)*

by G. Hughes
P.O. Box R307 Royal Exchange
Sydney 2000

INTRODUCTION

The dorsal colour of the Black-headed Python is light to dark brown with numerous dark cross bands on the body and tail. The ventral colouration is creamish, sometimes with dark blotches. The head, neck and throat are glossy black.

Details of the three snakes used in the breeding programme are:

	SIZE	WEIGHT	LOCALITY
Female No. 1	1.7m	2300gm	Mt. Isa
Female No. 2	1.6m	2150gm	captive bred
Male	2.1m	2500gm	Cape York

HOUSING AND FEEDING

All three animals are kept in a number of different cages throughout the year, sometimes together, sometimes separate. Prior to mating they are placed in separate glass fronted cages measuring 1200 x 600 x 900mm. These cages are heated using 60 or 75 watt spot bulbs with a thermostat control. Cage temperatures vary considerably throughout the year. In winter temperatures range between 20-22°C and in summer from 26-31°C with the cage temperature sometimes reaching 34-35°C on very hot afternoons.

The feeding of these animals is normally every 7-10 days during September to April, a normal feed being 5 mice or 1 medium sized rat.

MATING AND EGG LAYING

1988: Female No.1 and the male mated during the June, July and August. The cage temperature was a constant 22°C with a slightly warmer spot on the floor of the cage. The animals were together for 2 days followed by 5 days apart. This cycle was repeated continuously over the three months.

1989: Female No.1 and female 2 mated with the male during June, July and August. The system was changed with the male spending 3-4 days with each female, with a period of 2 or 3 days rest in between. Normally mating would take place within one hour of the animals being placed together and last up to eight hours. Because of the large size of the unfertilised eggs when the female is ovulating she may appear to be gravid. For this reason I continue to mate the snakes for as many weeks as possible.

By the beginning of September the females show signs of being gravid. Initially it is recognised by their refusal to eat, then as the weeks pass a gravid female will be found coiled in the most unusual positions, including almost belly up. By now the eggs can be counted.

In the 1988 mating, female 1 laid her eggs on some newspaper on the floor of the cage. This was directly above the heating lights from the cage below. In the 1989 mating, female 1 laid her eggs in a plastic container with damp vermiculite and leaves.

All three layings took place in daylight hours and all eggs were laid in October. The two clutches from female 1 numbered 8 eggs each. Each clutch was approximately 1kg. The one clutch from female 2 numbered 6 eggs and was 750gm in weight. The average size of the eggs from

all three clutches was 100mm x 50mm with the largest egg measuring 110mm x 55mm and the smallest egg 95mm x 45mm.

INCUBATION AND HATCHING

The incubator I use is constructed of 13mm chipboard. It measures 900mm x 450mm x 900mm high, divided horizontally into three sections, the bottom containing three 60 watt incandescent bulbs.

The heat from these bulbs rises through the peg board to the middle section. The top section has dowel racks on which the containers holding the eggs are placed. These two plastic containers measure 450mm x 380mm x 300mm. To these I add 1450gm of vermiculite and 500gm of water giving a 65/35 mixture. These quantities give a 70-80mm depth. The containers are covered with clear plastic (gladwrap). The sensor for the thermostat lies on top of the vermiculite with the eggs. A thermometer is also placed with the eggs to obtain accurate temperature readings. The containers are then covered with paper so the eggs are incubated in darkness.

In 1988 the clutch from female 1 was incubated in 50/50 by weight of vermiculite and water. Incubation temperature was 30-31°. All eggs were dead after 30 days and were found to be fertile but had stopped developing at an early stage.

The 1989 clutch from female 2 (laid 4 October 1989) was incubated in 65/35 vermiculite and water at 30-32°C. All eggs were fertile but died after about 7 days.

The 1989 clutch from female 1 (laid 1 October 1989) were incubated in the same medium and at the same temperatures as for female 2.

Hatching of this clutch commenced on 4 December 1989 (65 days after laying) when the first head appeared from one of the eight eggs during the afternoon. I waited until 10pm that night for the other eggs to be slit. When none had I made a 25mm cut in each of the remaining seven eggs. Over the next six days all the young emerged from the eggs. Of the seven eggs slit by me only two of the young emerged from these slits.

The young ranged in size from 500mm to 630mm with the average length being 571mm. Weight ranged from 50gm to 75gm with the average being 63.5gm. All eight neonates had sloughed 17 to 20 days after hatching.

The first hatchling to feed by itself did so after 30 days when it took a pink rat. The rest were force fed new born mice for up to 90 days after hatching. All were good feeders by 4 months of age.

WANTED: PHOTOGRAPHS/SLIDES OF GOANNAS

I am engaged in a major review of the entire Varanidae, and photos of living specimens provide needed information on colour, pattern, and body proportions. Will buy or make copies. Also interested in reprints of any varanid materials. R.G. Sprackland, Dept. of Herpetology, California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118, U.S.A.

CAPTIVE BREEDING OF THE INLAND TAIPAN *OXYURANUS MICROLEPIDOTUS*

Peter Mirtschin
Venom Supplies
PO Box 547
Tanunda S.A. 5357

INTRODUCTION

Oxyuranus microlepidotus has been reported by Broad *et al* (1979), as the snake with the world's most toxic venom, being approximately 50 times more toxic than the Indian cobra *Naja naja*. Although it was known in the late nineteenth century from 3 specimens, surprisingly, it escaped true recognition until 1967 when a serious snake bite occurred in south-western Queensland. After its reclassification by Covacevich *et al* (1980), toxicity studies by Broad *et al* (1979) and Fohlman *et al* (1979), it generated much interest both in herpetology and toxinology. To date, despite a reasonable number being kept in captivity, the species hasn't proved easy to breed. Information is presented here on two successful breedings of this species.

FIRST BREEDING

The male was collected in April 1980, Mirtschin (1981), and the female in March 1981, (Mirtschin and Reid (1982), both from Goyders Lagoon, South Australia.

Both snakes were separately displayed at the Whyalla Fauna and Reptile Park. The female was reluctant to feed through the winter despite being provided with necessary temperature requirements of 25-28°C and only fed twice until August when she began feeding voraciously. They were placed together early in September 1983 and courtship began on 24th September 1983 and continued through until at least 25th October 1983. Copulation was not observed. The female was transfered to an offshow early in November after no further courtship was observed. Oviposition occurred on 25th December 1983 and 11 eggs were laid. The eggs were placed in plastic containers with very damp peat moss and a sheet of aluminium foil over the top (see Fig.1) The eggs in the plastic containers were incubated at about 27°C. Half way through incubation, 4 of the eggs began to collapse and discolour. One was sacrificed and slit open only to find the partially developed snake was still alive (blood could be seen coursing through blood vessels under magnification). The other 3 discoloured eggs were left in their containers, however towards the end of incubation all had shrivelled to hard masses. When they were cut open after the other eggs had hatched, they were found to be dead and only partially developed. Hatching began on 27th February and was complete on 3rd March 1984 with 7 juveniles successfully hatched. Some of the courtship, oviposition and hatching was recorded on video and is featured in a television documentary "Snakes and Us" 1984 by Spencer Gulf Telecasters. Hatching details are provided in Table 1.

SECOND BREEDING

The same male as in the first breeding, and a female collected in April 1987, also from Goyders Lagoon, South Australia.

The male was mainly on public display at the Whyalla Fauna and Reptile Park. The female was kept off display in a venom extraction facility at the same Fauna Park.

On the 4th September 1989, the female was placed with the male in the vivarium. No interest was shown by the male. On the 6th September 1989, the female was returned to her own cage. The female was again placed with the male on the 13th September 1989 but on the next

day a swelling in the bottom jaw of the male was noticed. Both were then removed to the offshow venom extraction facility.

An oral culture was taken from the male, and *Pseudomones sp* was identified. An oral course of metronidazole benzoate (40mg/ml) was administered using a syringe and a plastic catheter as well as an intramuscular course of gentamicin was commenced with 0.10ml on the first day and 0.08ml on the remaining 6 days (the snake weighed about 1.8kg). The metranidazole benzoate was given at 1.5ml for the first day and then 0.75ml for the remaining 6 days. All swelling disappeared and the male was returned to his cage on the 23rd September 1990.

The female was placed with the male again on 5th October 1989. Courtship behaviour was noticed on the 6th, 8th and 9th of October 1989 after which interest by the male subsided and the female was returned to her cage on 11th October 1989.

On the 20th October 1989, mouth swelling in the male returned and *Pseudomonas sp* was again isolated from a mouth swab. This time it was decided to treat for a longer period to try and eliminate reinfection. Gentamicin was administered as before for 10 days starting on the 22nd October 1989 with 0.1ml on the first and second days and then finishing with 0.08ml for the remaining 8 days. Metranidazole benzoate was again given for 6 days at 1ml per day. Again the infection cleared and the snake's mouth appeared to be normal.

On the 5th November, the female was placed with the male in a cage in the offshow area and immediately the male showed interest. On the 6th November 1989, blood was found smeared over the newspaper on the bottom of the hide box. The male at this time was not showing any interest in the female. No injury could be found on either snake and it was assumed that the cause was hemipenal bleeding by the male from the female dragging him by the hemipene after copulation.

Another female was introduced and temporary interest was shown by the male. Attempts to feed the male were made since it had shown no interest in feeding during the preceding mating attempts and treatments. It showed no interest in feeding, so another female was introduced. Although some interest was shown by the male, it then appeared neither interested in food or mating. Examination of its mouth on the 13th November 1989 again revealed that the infection had returned. Treatment with gentamicin was given for 6 days at 0.08ml per day. On 28th November it died. A postmortem carried out on the snake reported "fair body condition; urate deposits in lung; a few pale areas in the liver; kidneys pale with prominent lobules and containing urates. Death likely due to renal failure".

By about the 10th December 1989, the female was determined to be gravid by palpitating egg masses in the abdomen. On the 11th December, Venom Supplies transfered all snakes to a new location in Tanunda, so the female had to endure a 6 hour road journey to the new location. The transfer was done at night to minimise heat stress. On the 28th December, the female laid 11 eggs.

The eggs were placed in plastic containers similar top those described in the first breeding except that they were half filled with moist vermiculite, 50% water and 50% vermiculite by weight. Instead of tin foil a fine plastic film (food wrap) was placed directly over the eggs/vermiculite. The container was housed in an incubator set between 28-30°C. Apart from brief periods when the incubator thermostat required readjustment and was accidentally unplugged, the incubation period was uneventful and adhered to the set temperature range. Moisture was sprayed onto the eggs when they started to dry out as indicated by slight collapsing of the eggs.

Between the 11th and 14th March 1990, 10 of the 11 eggs hatched. The 11th egg developed full term but the neonate was deformed and had died before the egg was opened for inspection on 12th March 1990. Hatching details are presented in Table 2.

DISCUSSION

The incubation times of 65 and 72 days, mating in October and November, oviposition times in February and March and clutch sizes of 11 are within data limits presented by Shine and Covacevich (1983), but the SVL form 385 to 420mm in these breedings is considerably higher than their inferred SVL of 300-340mm for this species.

The information published here and in Shine and Covacevich (1983), only represent a fraction of the total ecological picture of this species. In the interests of conservation of this species, greater access should given to interested persons by the statutory authorities so that further captive studies can be undertaken.

Table 1.
Hatching Details of the 1983/84 Breeding

Spec. No.	Sex	SVL (mm)	Total Length (mm)
1	-	410	490
2	-	415	475
3	-	400	470
4	-	400	470
5	-	415	470
6	-	410	475
7	-	385	445
8		did not hatch	
9		did not hatch	
10		did not hatch	
11		did not hatch	

Table 2.
Hatching Details of the 1989/90 Breeding

Spec. No.	Sex	SVL (mm)	Total Length (mm)
1	F	400	465
2	F	378	439
3	F	410	475
4	F	420	485
5	F	410	480
6	M	390	455
7	M	395	457
8	M	390	458
9	M	415	490
10	M	410	480
11	did not hatch-deformed		

ACKNOWLEDGEMENTS

To Peter Hudson and Paul Fennell for their assistance during the first breeding.

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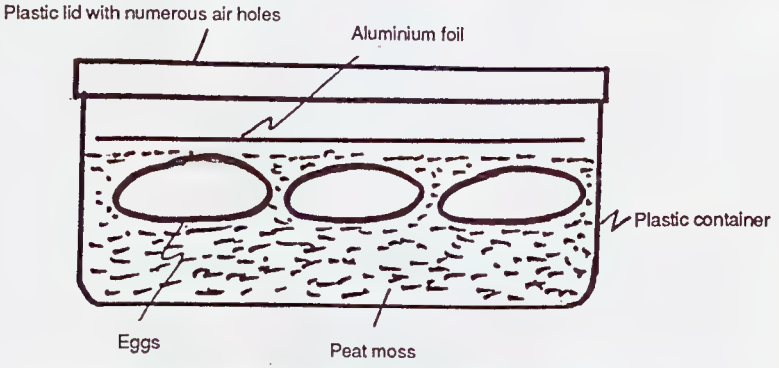

Figure 1. Egg Incubation System for First Breeding

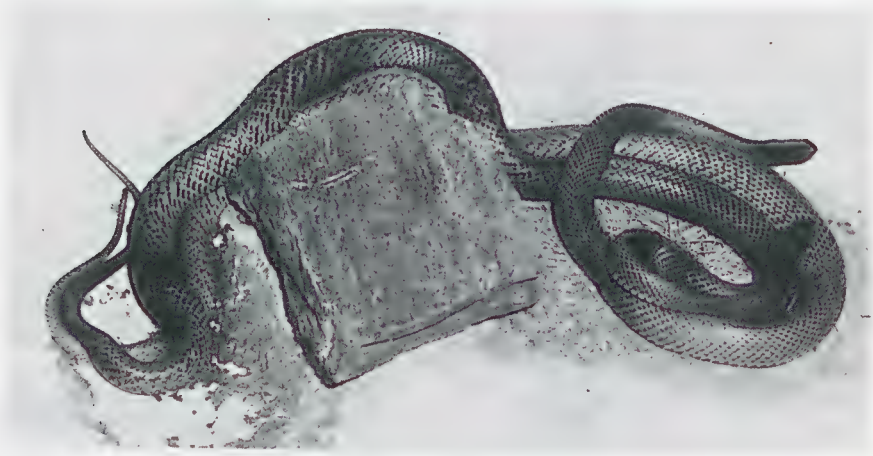

Figure 2. Inland Taipans Mating

NOTES ON THE CENTRAL CARPET PYTHON *MORELIA SPILOTA BREDLI*

Greg Fyfe
PO Box 505,
Alice Springs N.T. 0871

INTRODUCTION

The Central Carpet Python is a medium size member of the *morelia spilota* species group. Previously considered part of the variation exhibited by *Morelia spilota variegata*, it was described as a full species, *Python Bredli*, by Gow in 1981. Some workers have followed Gow (Cogger 1986; Wilson and Knowles, 1988), while others continue to regard the taxon as a sub-species of *M. Spilota* (Smith, 1985; Hoser 1989).

After measuring a variety of characters in museum specimens of the *M. spilota* species group, I regard bredli as a sub-species (G. Fyfe, unpublished data). My investigation of this group is continuing and the results will be presented elsewhere.

M.s.bredli is a reasonably common animal throughout its range at present but because it occurs in a remote area it has attracted little study in the field or in captivity.

RANGE AND HABITAT

Morelia spilota bredli is confined to the central ranges and major river systems in the southern sector of the Northern Territory. Gow (1981) cites a record from The Granites, in the Tanami Desert, which seems to be the northern-most record. It is widespread in the Hart and Macdonnell Ranges, and their associated watersheds, and has been found at Henbury Station on the Finke River to the south (M. Gillam, pers. comm.).

This sub-species is closely associated with rocky gorges in the ranges or with riverine trees and shrubs in flatter areas. It generally shelters in tree hollows, rock "caves" or around rabbit warrens adjacent to tree-lined rivers and creeks.

ACTIVITY PERIODS

Whilst generally considered to be nocturnally active, this sub-species can often be found active during the day. In spring and autumn, this is usual because the night temperatures are too low for activity. During summer, individuals may bask in the mornings or spend the entire day high in the canopy of trees. Basking snakes may be found on the ground, on rock slopes, adjacent to rabbit burrows or in trees at tree hollows or in the canopy. Summer nights may be spent on the move because temperatures are more suitable at this time.

COLOURATION

The sub-species has been described in recent works (Gow, 1981, 1989; Cogger, 1986; Wilson and Knowles, 1988) but more should be mentioned on colouration. The colour in the field is often a rich orange red with pale spots and bands being almost yellow - particularly towards the end of the tail. The pale markings are usually bordered by a single scale row of black. This bright colour tends to fade over a period of 1-3 months in captivity, to a dark reddish brown with fawn or putty coloured pale markings, the black edges being hard to notice. The reason for this change is not apparent at this stage but it may be due to light intensity or U-V light levels. Some field caught animals have this darker colouration and those that I have collected came from shelter sites that did not receive much sunlight (eg house rooves, sheds and heavily shaded rock gorges).

Gow (1981) describes the colour of juveniles as - "pattern resembles adults, but more pronounced due to colouration". This is certainly true of animals between 60cm and 140cm in length but it is not true of neonates and very young specimens. These very young snakes have the same pattern as adults but differ in colour. They are usually a dusty red brown with pale markings being grey - sometimes edged faintly darker. This darker edge becomes blacker as the snake grows, the grey becomes fawn and then yellowish, while the base colour becomes progressively more reddish orange. Gow (1989), pp 40 and 64) shows a photo of a young specimen.

SIZE

M.s.bredli commonly grows to a length of around 2 metres, and I have seen about 10 specimens over 2.4 metres total length out of about 100 animals observed. The largest specimen accurately measured by me was 2.6 metres total length, although old photographs and reliable reports indicate that occasionally an exceptional specimen may reach around 3 metres in length. Large adults 2 metres and over are usually docile and can be handled, whereas specimens under 1.5 metres in length are more likely to defend themselves vigorously!

FEEDING

Morelia spilota bredli has been recorded eating prey up to the size of rock wallabies *Petrogale lateralis* (I. Cawood, R. Darken, pers. comm.) and has been seen to coil high in river side where small birds "mob" them, the snake "plucking" birds from the air if they venture too close (M. Gilliam, pers. comm.). Tree-hollow dwelling wildlife such as galahs *Cacatua roseicapilla* and possums *Trichosurus vulpecula* (formerly common - now rare in Central Australia) would also be taken. Most larger specimens are found in areas where rabbits are common, sometimes being seen at warren entrances. A 2.0 metre captive specimen had no difficulty in killing and eating a 3/4 grown feral cat *Felis catus* that disturbed its slumber. In captivity, smaller specimens are usually eager to feed on mice or birds and most accept guinea pigs. Strangely, most will not accept rats and need to be "trained" to eat them. Most wild caught specimens (2.0 metres and over) are reluctant to feed in captivity.

REPRODUCTION

Gow (1981) records clutch sizes of 13 and 47 for this sub-species. The female incubated the latter egg mass which hatched after 10-12 weeks (70-82 days). Hatchling length was approximately 30cm total.

It is likely that this sub-species is a seasonal breeder, breeding in spring like other temperate zone reptiles. Although a desert area, Alice Springs is characterised by cold winter temperatures in June and July which prohibit much reptile activity. Pairs of *M.s.bredli* have been found basking close together in August and September and at least some of the female snakes appeared to be ovulating or gravid. During September 1989 a 1.8 metre female snake was seen basking close to a tree hollow. Investigation of the hollow the remains of approximately 70 old hatched python egg shells (A.Brown, pers. comm.), indicating that the tree hollows can be utilised as egg incubation sites. Recent hatchlings have been found in the field during January and February.

During July 1989, a 2.0 metre captive female *M.s.bredli* was mated by a 1.8 metre male of the same sub-species. The male had been housed separately for several months prior to being introduced to the female's cage. Matings were noted on July 24, August 2, 3, 5, 12, 15, 19, 21, 26, 29, September 1, 21 and 22. Matings were always noted in the mornings with unions lasting several hours in all cases. The female refused food from 26/8/89 and was housed separately from 23/9/89. On the morning of 20 November the female was found coiled around an adherent egg mass containing 16 eggs. All but two eggs were normal. These were "pointy ended" and one was half the size of the other 15.

All eggs were removed from the female and carefully separated into 2 batches for artificial incubation. The eggs were placed on coarse vermiculite, moistened with an equal weight of water and placed in plastic containers in a wooden incubator. The incubator was thermostatically controlled to maintain a temperature of 30°C. After three weeks the half sized egg died and was discarded. After 67 days the remaining 15 eggs began to hatch, 2 on 26/1/90 and 13 on 27/1/90. All hatchlings remained in the slit eggs for 8-12 hours before emerging fully.

Table 1. shows the lengths and weights of the neonate pythons. It can be seen that mean length and weight are greater than those calculated by Gow (1989) for this sub-species (300mm 15gm). They are however within the general range of hatchlings *M.s."variegata"* quoted by Charles *et al* (1985) (svl 320-430mm 20-35gm) and it is probable that *M.s. bredli* exhibits a variable birth size and weight like other Australian pythons.

The sex ratio of the hatchlings was determined by gentle probing with fine nylon fishing line and was 6 male : 9 female. The neonates all sloughed 2-3 weeks after hatching. They showed no interest in baby mice (pink or haired) and it is probable that they initially prey on scincid lizards or geckoes in the wild.

Table 1.

Lengths and Weights of Hatchling *M.s.bredli*

	Snout-vent Length (mm)	Weight (gm)
1	395	29.5
2	400	26.5
3	400	29.5
4	410	29.0
5	420	30.5
6	405	27.0
7	400	27.5
8	395	28.5
9	405	28.0
10	390	27.0
11	405	29.0
12	405	30.0
13	395	28.5
14	350	24.0
15	400	29.5
Mean	**398.3**	**28.2**

ACKNOWLEDGMENTS

I would like to thank the many people in Alice Springs who helped with the creation of this article by way of their willingness to pass on their observations of *M.s.bredli* in the field and in captivity. I particularly wish to thank Conservation Commission of N.T. rangers I. Cawood and R. Darken; and herpetologists Mike Gillam and A. Brown. B. Barnett was a continual source of advice and enthusiasm and the captive breeding recorded here owes much to his influence. Alan Thorne kindly reviewed an early draft of the article.

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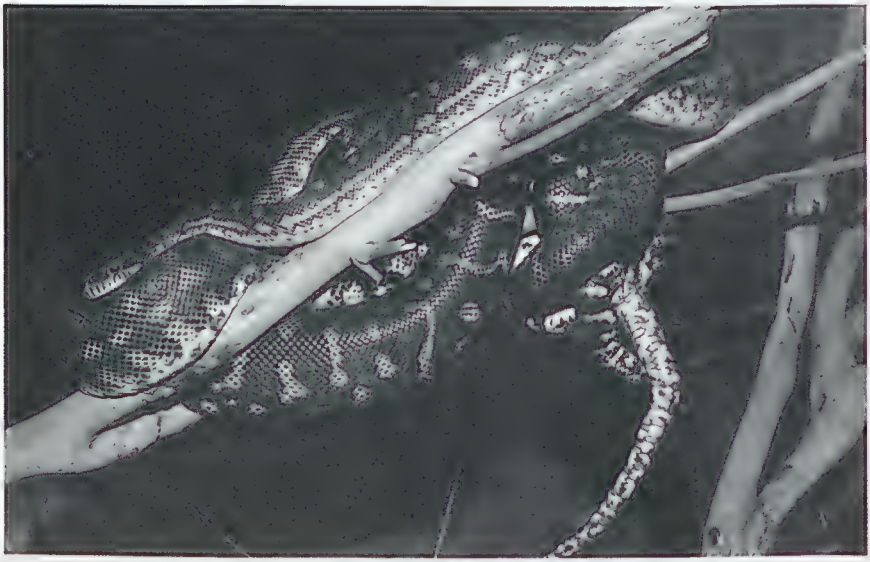
Figure 1. *Morelia spilota bredli* Mating



THE PETER RANKIN TRUST FUND FOR HERPETOLOGY

A Report on the First Decade

Allen Greer,
The Australian Museum,
6-8 College Street, Sydney 2000

The Peter Rankin Trust Fund for Herpetology has been in existence for ten years and as it enters its second decade a review of its achievements and a restatement of its original purpose may help introduce a new generation of young herpetologists to the Fund's benefits.

The Fund was established in 1979 to commemorate the memory of Peter Rankin, a young herpetologist who died accidentally while collecting in New Caledonia shortly after having graduated from university. Peter was passionately interested in herpetology. He kept many species of snakes and lizards, he travelled widely in Australia on field work, and he worked with a number of well known herpetologists. He published several papers, some in this journal. Peter was also often broke or near to it and would often scrimp, beg, borrow and charm his way toward the completion of his various herpetological projects.

After Peter's death, his friends, colleagues and family got together to think about ways to perpetuate Peter's memory and his passionate interest in herpetology. Hal Cogger conceived the idea of a fund to which people like Peter could apply to help carry out their herpetological projects. The fund was started with an investment capital of $10,000.00 and the first call for applications was made in 1981. Today the capital stands at $21,330.00, having grown through tax deductible contributions and reinvestment of accrued interest. Contributions to the fund are always being sought in order to keep up with both inflation and increased demand.

The fund's application requirements are simple. An applicant can be of any age, nationality, and level of expertise but he or she must be a resident in Australia and not be in paid employment in herpetology. The application itself requires only: a brief statement of the project (project proposals of more than one page are discouraged) written in simple language, a brief budget, and a completion date. In accepting an award the recipient agrees to abide by all state and federal laws, to submit a brief summary at the end of the project, and to acknowledge the fund in any publication.

Applications can be made at any time, but a formal call is made each year in about June with a submission deadline of 31 July. Decisions are made by 30 August. The formal committee for the fund consists of Hal Cogger and Allen Greer, both herpetologists at the Australian Museum and Neil Rankin, Peter's father. However, a number of other Museum staff and associates as well as members of Peter's family read the applications and have a strong influence on the committee's decisions. The committee has definite biases which favour a relative lack of experience but enthusiasm of the applicant, and simplicity of the project. The committee also tries to make awards to applicants in different parts of the country.

Currently the committee dispenses approximately $2,000.00 per year in awards in amounts of $50.00 to $1,000.00. Over the past decade the fund has had 90 applications made to it and has dispensed a total of $15,618.52 to 39 recipients. The number of awards by state or territory is ACT 4, NSW 18, NT 1, QLD 4, SA 8, TAS 0, VIC 1 and WA 3. A brief resume of the recipient, state or territory, amount and project title follows.

Name	State	Amount $	Project
1981 (total number of applications = 11)			
Fitzgerald, M.	NSW	200.00	Parasitic nematodes in snakes.
Georges, A.	NSW	220.00	Survey of Krefft's River Turtle *Emydura krefftii* on Fraser Island.
Parker, R.	QLD	160.00	Tagging of Flatback Turtles *Chelonia depressa* on Fraser Island.
Shea, G.	NSW	500.00	Variation in the Shingleback *Tiliqua rugosa.*
		1080.00	
1982 (3)			
Burns, C.	NSW	480.00	Reproductive biology and population ecology of sea snakes.
Delean, S. and C. Harvey	SA	426.00	Biology of Knob-tailed Geckos *Nephrurus.*
		906.00	
1983 (5)			
Donellan, S. and M. Mahoney	NSW	500.00	Speciation in the *Litoria lesueuri* complex of frogs.
Gidings, S.	SA	71.00	Artificial insemination in reptiles.
Else, C.	NSW	500.00	Evolution of mammalian metabolism from reptilian metabolism.
Johnston, G.R.	SA	300.00	Morphological variation in the agamid lizard *Amphibolurus fionni.*
Moritz, C.	ACT	600.00	Morphometric analysis of the bisexual and parthenogenetic species of Bynoe's Gecko *Heteronotia binoei.*
		1971.00	
1984 (4)			
Chester, G.	ACT	289.00	Response of the frog eating Green and Golden Bell Frog *Litoria aurea* to calls of potential prey species.
Slip, D.	NSW	492.00	Telemetry in Diamond Pythons *Morelia spilota.*
		781.00	
1985 (12)			
Field, R.	QLD	335.10	Reproductive biology of Australian pythons.
McKeown, P.	NSW	60.00	Observations on she oak skinks, blue-tongued skinks and bearded dragons.
Medlin, A.	SA	200.00	Taxonomy of the tree frogs *Litoria caerulea and L. gilleni.*
Robinson, D., B. Maryan, and R. Browne Cooper	WA	570.72	Reptile survey of Coleenup I., WA
		1165.82	
1986 (8)			
Connell, G.W.	WA	350.00	Social aggregation in the skinks *Egernia kingii and E. multiscutata.*
Dillon, M.	NSW	277.20	Development of the *Crocodylus johnstoni* pituitary.

Johnston, G.R.	SA	500.00	Ecological and morphological variation in *Amphibolurus rufescens.*
Kennett, R.	ACT	481.00	Reproduction and growth in two populations of the Long-necked Tortoise *Chelodina longicollis*
Richards, S.J.	SA	210.00	Colour morphs of the Brown Tree Frog *Litoria ewingi.*
		1818.20	
1987 (8)			
Frappel, P.	SA	590.00	Effect of temperature on the mechanics of respiration in the Central Netted Dragon *Ctenophorus nuchalis.*
Heaphy, L.	NSW	300.00	Aspects of the population dynamics, diet and physiological ecology of the Pig-nosed Turtle *Carettochelys insculpta.*
Sarre, S.	SA	590.00	The genetic impact of isolation on seven island populations of the Shingleback *Tiliqua rugosa.*
Schwartzkopf, L.	NSW	420.00	Costs of reproduction in viviparous skinks: effects of reproductive activity on individual fitness.
		1900.00	
1988 (3)			
Lemckert, F.L.	NSW	225.00	Population dynamics and reproductive biology of the Common Eastern Toadlet *Ranidella signifera.*
Pollock, D.C.	VIC	390.00	Change of diet and digestion with age in Cunningham's *Skink Egernia cunninghami.*
		615.00	
1989 (20)			
Cooper Preston, H.	NT	351.50	Development of technique for aging Freshwater Crocodiles *Crocodylus johnstoni.*
Dorrough, J. and N. Thorne	ACT	405.00	Behaviour and population distribution of the Water Dragon *Physignathus lesueurii.*
Hearnden, M.N.	QLD	550.00	Analysis of tadpole habitats.
James, C.D.	NSW	500.00	Travel to First World Congress of Herpetology.
Norman, J.	QLD	426.00	Biochemical analysis of breeding Green Turtle populations.
Richards, M. (for the AHS)	NSW	280.00	Herpetofaunal survey of Hawkesbury River islands.
Webb, J.	NSW	597.00	Pheromone trailing behaviour in blind snakes *Ramphotyphlops.*
		3109.50	
1990 (16)			
Downey, F.	NSW	750.00	Physiology of the Water Dragon *Physignathus lesueurii.*
Humphreys, G.	WA	422.00	Variation in King's Skink *Egernia kingii.*
Scanlon, J.D.	NSW	380.00	Squamation in the Eastern Tiger Snake *Notechis scutatus.*
Willis, P.M.A.	NSW	720.00	Taxonomy of Australian crocodilians.
		2272.00	
		15,618.52	

DEVELOPING HUSBANDRY TECHNIQUES TO BREED PYTHONS IN CAPTIVITY

by Ray Field
1 Faraday Street
Wulguru 4811

During the past 10 years I have bred pythons in captivity and artificially incubated many clutches of eggs. The species, Black Headed Pythons *(Aspidites melanocephalus)*, Children's Pythons *(Liasis childreni)*, Water Pythons *(Liasis fuscus)*, Olive Pythons *(Liasis olivaceus)*, Scrub Pythons *(Morelia amethistina)*, Carpet Pythons *(Morelia spilota)* and Green Pythons *(Chondropython viridis)* have collectively produced 358 eggs of which 285, or 80%, hatched.

Between 1980 and 1984 the hatch rate was 60% i.e. 61 eggs hatching from the 102 laid. From 1985 to 1990 the success rate was 87% i.e. 224 hatchings from 256 eggs laid. These figures include the failure of 17 out of 18 eggs laid by a Green Python. The eggs were laid from a branch in the cage and fell to the floor resulting in almost total failure. Exclusion of this mishap would increase the hatch rate to 94% i.e. 223 hatching from 238.

These records demonstrate that the husbandry techniques I use are effective over a range of species, effective over a period of time, and I believe improving as the increases in clutches and hatching percentages indicate.

This technique is based on "Seasonal Conditioning" and the calculated "Timing" of mating introductions.

It is necessary to draw on our knowledge of pythons in the wild to gain and develop techniques to use in captivity. To this end I have tried to piece together typical lifestyles or activity patterns of pythons, based on published literature, common knowledge, the thoughts of fellow herpetologists and my own observations.

In the tropics or at least in the Townsville area, pythons hatch at the start of the Wet Season, usually in December. Hatching coincides with the "Biological Rush" of the Wet Season. This is the time of the year that offers the best chance of survival, there is an abundance of suitable prey such as frogs, lizards and other small snakes. The warm weather ideally suits nocturnal feeders, pythons in the wild only occasionally take prey in daylight hours. Since there is no evidence to suggest that pythons have any social or communal interaction before sexual maturity, their existence revolves around finding food, water and shelter and avciding falling prey to other predators. This lifestyle is affected and determined by the seasons. Pythons feed after they slough and continue feeding until the cooler weather conditions of autumn inhibit their activities. Because they are reliant on external sources for heat and energy, the cold conditions are not conducive to nocturnal hunting or the digestion of food. Pythons find suitable shelter during winter and remain relatively inactive until the following spring, when the warming weather induces them to resume feeding. This feeding cycle peaks toward the end of summer, declines during autumn and ceases by winter. It follows inactivity during winter after which the pattern is repeated, determined by the seasons.

Having established the basic concept on "Seasonal Activity" it was necessary to review information on pythons breeding in the wild and captivity. There is sufficient evidence to suggest the following:

1. Pythons are seasonal breeders.
2. They tend to gather in small groups - "Mating Aggregations".

3. Males indulge in ritual and occasionally real combat.

4. Courtship occurs in the form of a crawling, following motion, performed by both sexes.

5. Males use their spurs in a raking motion to stimulate the female prior to copulation.

6. Cold weather influences or heightens sexual activity.

7. Initial reaction on the introduction of partners usually comes from the female in the form of passing fluids and occasionally blood.

8. Eggs are laid approximately 12 to 14 weeks after copulation.

9. Prior to laying the female often lays side on or in a belly facing upwards position.

10. Pythons slough approximately three weeks before laying eggs.

11. The eggs adhere to each other forming a solid mass when drawn together to form a clutch.

12. The weight of the eggs may equal more than 30% of the body weight of the female.

13. The female incubates her eggs and can control the temperature to an extent by a process called shivering thermogenesis.

14. Data taken from clutches monitored in the wild and in captivity, suggests that 30 degrees celsius may be the optimum incubating temperature.

15. High Humidity is essential in egg incubation.

16. Incubation period ranges from 7 to 14 weeks and is temperature and species variable.

17. Pythons exit their eggs by slitting the shell with a specially formed tooth.

In assessing data on breeding and seasonal activity I determined the need to duplicate the influences of the seasons and calculate a long term timetable to follow (see Figure 1.).

This timetable forced consideration of many aspects of husbandry including housing, individual specimen conditioning, climate control, and of course the timing of mating introductions, critical to success in breeding.

Eggs hatch in summer coinciding with the wet season, by counting back 10 to 12 weeks (average incubation period) we establish that the eggs are laid in October, by counting back 12 to 14 weeks (gestation period) we establish that mating would occur in July, in winter not in spring as much literature indicates. I introduce pythons for mating on the 1st July each year, and pursue their keeping with that goal in mind.

Figure 1.

TEMP. RANGE °C	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAY MAXIMUM	32	32	30	28	26	24	20	24	28	30	30	32
NIGHT MINIMUM	24	24	22	20	18	16	12	16	20	22	22	24

Notes: This is a temperature range suggested to match external seasonal conditions. Cage layout should allow the snakes to expose themselves to or to retreat from the heat source as desired. When females are developing eggs they tend to bask close to the heat source for long periods.

FEEDING	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
JUVENILES	✓	✓	✓	✓	✓				✓	✓	✓	✓
ADULT MALES	✓	✓	✓	✓	✓				✓	✓	✓	✓
ADULT FEMALES NOT PRODUCING EGGS	✓	✓	✓	✓	✓				✓	✓	✓	✓
ADULT FEMALES DEVELOPING & LAYING EGGS BUT NOT INCUBATING	✓	✓	✓	✓	✓				?		✓	✓
ADULT FEMALES DEVELOPING, LAYING & INCUBATING	✓	✓	✓	✓	✓				?			

Notes: Food offered to females developing eggs is rarely taken. Refusal is a good indication that the female is gravid. Because of loss of body condition in producing and incubating eggs and the accompanying short time to feed, females may not reach breeding condition the following year. They may breed every second year.

MATING INTRODUCTIONS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INTRODUCING FEMALE TO MALE							✓	✓				
EGG LAYING										✓	✓	
HATCHING	✓											✓

HOUSING

I house my pythons separately in 1200cm x 600cm x 600cm wooden frame cages with glass fronts, and peg board walls and roof. A light socket is built into the roof of each cage. Clear light bulbs of various wattages provide heat when necessary during the day and 40 watt blue bulbs provide heat when necessary at night. The use of dimmer switches and separate light sockets for clear and blue bulbs permits better climate control. Water is provided in plastic bowls that are difficult to overturn (food bowls for pets). The water is made available all year round.

A foam box, painted brown, is provided as an insulated hide, the box has a removable lid and a relatively small entrance hole. The timber floor is covered by fitted corflutes panels wrapped in unprinted newspaper. A smooth branch is fitted giving access to the heat source.

Apart from the branch the cage has no natural appeal, it is designed to permit climate control and easy cleaning.

Pythons kept in large naturally landscaped cages, particularly outdoor cages, tend to fare poorly in comparison to those housed in relatively small indoor cages.

CONDITIONING/FEEDING

Pythons should be fed nocturnally. Their feeding should be controlled using the seasons as the guide. Commence feeding in spring, guage the supply to peak by the end of summer, reducing to finish toward the end of autumn. The volume of food should be controlled to produce specimens neither obese nor underweight, males tend to be slightly slimmer than females.

Try to avoid stress to the animals by keeping handling to a minimum and by ensuring that their nocturnal activities are not disturbed by blinding artificial light.

CLIMATE CONTROL

I try to control photoperiod, temperature and humidity to duplicate seasonal conditions. Natural photoperiod is best achieved by positioning the cages so that the effect of day/night, night/day change is experienced by its inhabitants. It is not necessary for the cages to receive direct sunlight. In situations where cages cannot receive natural photoperiod it is necessary to provide the effect by turning on and off at daybreak and sunset respectively using photosensitive switches or timers.

Temperature control, observing the need to provide heat without light, was mentioned in the section on housing, refer to the timetable for further information.

A lack of humidity can cause dehydration and damage to delicate nasal membranes, resulting in infection and undue stress. Humidity is difficult to control without the use of a humidifier, but can be increased by using a simple water spray.

Climate is easy to control in Townsville. I have no experience in keeping pythons under the adverse conditions faced by keepers in cold climates.

MATING INTRODUCTIONS

In the wild pythons lead solitary lives without social or communal interaction, for this reason I house them separately.

As mentioned earlier I look to introduce my pythons together for mating on the 1st July each year. The introductions may be delayed or brought forward depending on the time of sloughing. The female is introduced to the male's cage. Usually within a short time the female locates the male and reacts by passing fluids and occasionally a small amount of blood. The male is usually slower to react and may show little interest until the overnight drop in temperature prompts courtship and copulation. After two to three days I remove the female and reintroduce again after a week. This process is repeated until interest in mating wanes, this may take from 3 to 8 weeks.

When the initial introduction produces no reaction from either sex I introduce other females or males or both in the same cage. In effect producing an aggregation. This grouping of the pythons usually produces the reaction from the females as previously described, and stirs the males into ritual combat. This combat is best described as a pushing bout involving the raising and lowering of the body in undulating motions, I think, to force the opponent down and away. The wrestling sometimes turns to biting which may inflict severe gashes.

EGG LAYING/INCUBATION

The incubation of python eggs is well documented. My practice is to remove eggs from the female and incubate them artificially. By providing high humidity and an even temperature of 30 degrees celsius I enjoy a high hatch rate. Because higher percentages of eggs have hatched from clutches grouped together by the female I allow the females to perform this task rather than place the eggs into the incubator individually.

Occasionally eggs reach full term but do not hatch. One such egg was cut open to reveal a number of slits in the inner wall of the egg. These were not deep enough to allow the python to hatch. After the first few eggs hatch I carefully cut a slit in the remaining eggs to assist hatching.

INITIAL FEEDING

New born pythons do not feed until after their first sloughing, about two weeks after birth. It is important to house them separately in small cages, offer suitable sized food at night, allow the pythons to locate and kill their first meal. Prey not taken within an hour of introduction should be removed and re-offered in a couple of nights. A second failure to feed may warrant a change in choice of prey.

Force feeding is the last resort. Every other option should be tried. Many problems associated with failure to feed are caused by unnecessary handling and failure to provide the right conditions.

GENERAL

I believe that the breeding of pythons in captivity will become almost automatic as keeping practices include seasonal influences. The protective legislation that has restricted the taking of reptiles from the wild has proved an unexpected bonus to amateur herpetologists in Australia by forcing keepers to take better care of their reptiles leading to breeding in captivity. The legislation has had a similarly positive affect on Zoos and Reptile Parks.

ACKNOWLEDGMENTS

My success in captive breeding is largely due to invaluable assistance from Brian Barnett and Neil Charles. I thank Joe Bredl, Bob Bredl and Peter Krause for sharing their knowledge and expertise, Peter Moran for the loan of Olive Pythons, Dr Rick Shine for assistance in publishing related papers and the Australian Museum for providing a grant from the Peter Rankin Trust Fund for Herpetology.

REVIEW OF AN UNSUCCESSFUL BREEDING OF BLACK-HEADED PYTHONS *(ASPIDITES MELANOCEPHALUS)* AT MELBOURNE ZOO.

David F. Leyden, Jon R. Birkett and Chris B. Banks
Herpetofauna Department, Royal Melbourne Zoo,
P.O. Box 74, Parkville,
Victoria 3052, Australia.

INTRODUCTION

The Black-headed Python *(Aspidites melanocephalus)* is a large, well-known snake reaching an average total length of 1.5m (Cogger, 1986). It is nocturnal and found throughout northern Australia in a wide range of habitats from wet coastal forests and woodlands to arid grasslands of the interior.

Melbourne Zoo currently has five specimens (two males, three females), which have all been received over the last 3-5 years:

MALE			FEMALE		
	Weight (kg)	Total length (m)		Weight (kg)	Total length (m)
#1	4.0	2.193	#2	3.7	2.049
#4	5.7	2.460	#3	4.0	2.109
			#5	7.3	2.605

(all measurements as at 1 August, 1990).

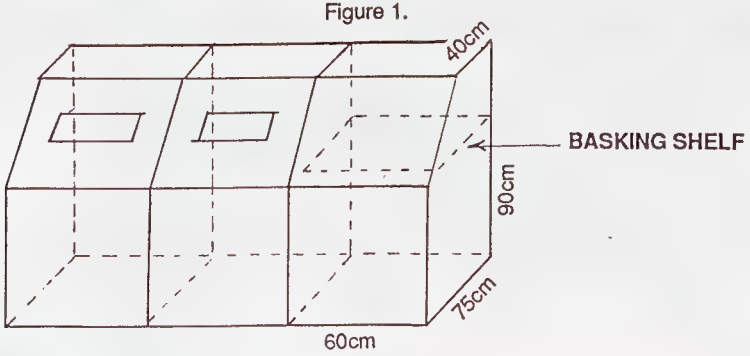
HOUSING

From late August to early April the following year, all five snakes are housed together in a large display enclosure (2.0 x 2.7 x 1.8m high). The enclosure is landscaped to represent a section of semi-arid habitat, furnished with large branches, a red sandy soil substrate, and a small shallow pond at the base of an artificial rock-face.

The enclosure is maintained at 24-35°C by thermostatically-controlled substrate heating. Three supplementary basking sites are provided by 250W infra-red heat lamps, positioned above the enclosure directly over easily-accessible rock ledges and branches. A natural photoperiod (for Melbourne) is provided via clear corrugated fibreglass roof sheets, and additional lighting is supplied by fluorescent lights connected to timers.

When not on display, all snakes were held in off-limit holding boxes (Fig. 1). These are heated by two thermostatically-controlled 40W blue light globes and one 15W clear inspection light. A clear perspex basking shelf in each box allows the pythons to regulate their temperatures.

Figure 1.



Gravid females held in the boxes were also provided with polystyrene nesting boxes (600 x 350 x 200mm) containing moist vermiculite and sphagnum moss.

BREEDING

Male #1 was observed spurring, courting and attempting to copulate with two of the females on display in early April 1989, after an eight week period off display for treatment to a bite. He was removed from display the following day as one of the females (#5) was only days from sloughing. The male was returned to display three days later following female #5's slough. He was removed after a further three days as he showed no interest in the females. Short introductions to the females, of 1-3 days, then occurred approximately every 7-14 days over the next eight weeks. During these introductions, the resident male (#4) was removed from display. Whilst in the holding boxes male #1 was cooled by turning the heat lights off in the evening and on again in the mornings. Over this period, floor temperatures in the boxes ranged from 16-31°C (Fig. 2) and shelf temperatures from 16-52°C (Fig. 3).

Breeding activity was observed during every introduction, usually involving male #1. However, he appeared to lose interest in the females in mid-July and, approximately one week later, male #4 was observed courting and mating females #3 and #5. This was repeated on four occasions over the following six weeks. Both males were removed from display in early September, despite mating behaviour still being observed. This allowed the then-gravid females to be undisturbed over the last 5-6 weeks prior to laying. On 25 September, both males were returned to display and both females were transferred to the holding boxes. However, neither male showed interest in the remaining female (#2).

Figure 2.

Minimum, Maximum Floor Temperature

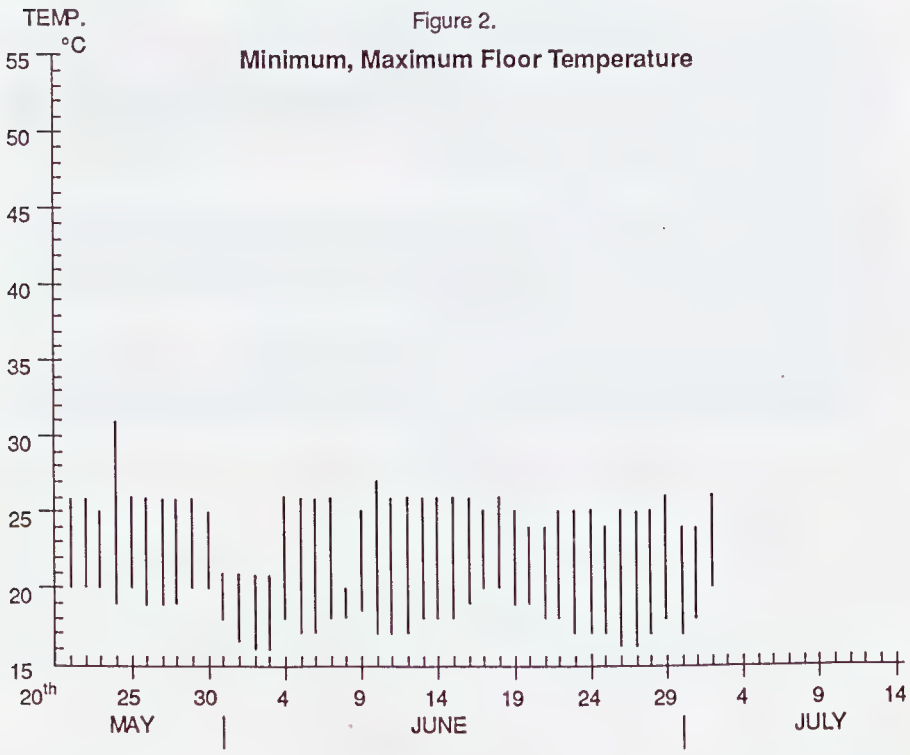
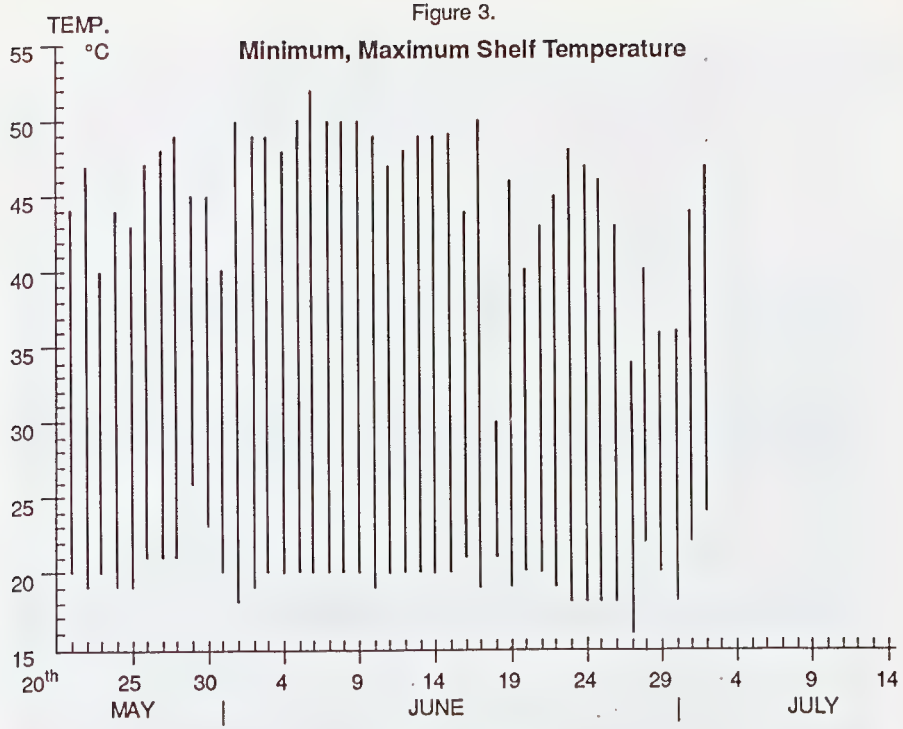


Figure 3.



EGG LAYING

In early August, females #3 and #5 appeared to be slightly distended over the last third of their bodies. All females were then gently palpated and uniformly-spaced, evenly-sized masses of about 25mm diameter were felt. Ten days later they were palpated again and the masses seemed to be larger and the swelling was more uniform, indicating egg development. Females #3 and #5 were observed laying partly on their sides or completely upside down over the next five weeks. They were removed from display on 25 September, two weeks after their last slough, to separate holding boxes to allow for better environmental control. Female #2 remained on display as her masses did not develop.

Females #3 and #5 spent most of their time in the nest boxes, only leaving them to bask for short periods. On many occasions, they were seen lying upside down or on their sides in the boxes.

Both females laid their eggs in the boxes provided; #3 on 12 October and #5 on 16 October. While they were coiled around their egg masses, the eggs were completely raised off the floor by the snakes' coils and tails.

Female #3's clutch (clutch #1) comprised six eggs:

Weight of egg mass:	775.2g
Mean egg weight:	129.2g
Mean egg length:	98.1mm (93.5 - 110.0)
Mean egg width:	47.8mm (47.0 - 51.0)
Pre-laying slough:	29 days prior.

Female #5's clutch (clutch #2) contained 14 eggs:

Weight of egg mass:	1406.1g
Mean egg weight:	100.4g
Mean egg length:	77.8mm (75.0 - 81.0)
Mean egg width:	48.8mm (45.0 - 52.0)
Pre-laying slough:	29 days prior.

INCUBATION

Both clutches of eggs were artificially incubated in large plastic containers in an Isolette Infant Incubator at a temperature range of 27 - 30°C in moist vermiculite (vermiculite: water at no set ratio). One infertile egg was discarded from clutch #1 after seven days. During early incubation, both clutches of eggs were checked every 2-4 days and water was added. This practice continued over the next four weeks as the containers were not air-tight and the mixture appeared to dry out slightly. By 41 days, the eggs in clutch #1 appeared to have grown and one egg was found to have increased by 3mm in length and 10mm in width. Whilst measuring this egg, two other eggs in this clutch were seen to have small pin holes through which albumen was leaking. Selotape was applied over the holes to prevent further leakage.

After 69 days, one egg from each clutch was slit to check embryo development, as they were thought to be overdue. Each contained an embryo that appeared to be developing well as movement was seen; however, the scales showed no pigmentation. These two embryos had died by the 84th day, as a result of very small flies laying eggs in the containers. The presence of these flies had been noted the week before and attempts had been made to remove both them and pupae from the containers. The two python eggs concerned were carefully separated from the rest of their respective clutches.

By day 100, the whole of clutch #1 was discarded as all eggs were dead, but fertile.Total length of three of the dead embryos ranged from 370-515mm. The remaining 13 eggs from clutch #2 were discarded after 116 days, also following fly infestation. All these eggs were opened to again reveal well-developed, dead embryos.

DISCUSSION

There are very few records of the captive breeding of *A. melanocephalus* and even these appear to be one-off events rather than repeated breeding where all the relevant factors are known (Barker, 1984; Boos, 1979; Murphy *et al.*, 1981). Past attempts at keeping this species at Melbourne Zoo have met with little success and it is likely that the temperatures provided were too low. In this regard, data obtained from the Bureau of Meteorology on temperature ranges from five areas of northern Australia, within the range of *A. melanocephalus*, were valuable in assisting us to set the temperature ranges used here.

Copulation and oviposition dates, and egg dimensions, are within the ranges previously recorded for this species, allowing for the seasonal differences for northern hemisphere breeding (Boos, *op. cit.;* Murphy *et al., op. cit.*). A successful breeding at Dallas Zoo, Texas, differed significantly from this report in two respects - the female was introduced to the males (followed by rotation of the males), and spraying with water was used as a mating stimulus. Prior to this report, the largest clutch size was 12 eggs (*Boos, op. cit.*).

As well as the provision of a suitable temperature range in itself, we feel that providing access to heat and basking sites, and significant daily temperature fluctuations, are important. Two additional factors which we also consider are important for success with this species are separation of the reproductively-active male from the females, and ensuring that the females are in prime condition prior to the breeding season. We are also exploring this latter point with

Morelia spilota variegata, and are now regularly weighing our *A. melanocephalus* to obtain quantitative data. It should be noted, however, that introduction of females to males has also been successfully utilised for other species, e.g. *Morelia amethistina* (Grow *et al.*, 1988). We have used both methods (male to female and female to male), but note that males appear to lose interest in females if they remain together for long periods.

The incubation failure was initially due to the incubating medium being too wet, causing the eggs to swell and rupture. It is thought that this then attracted the flies, with the subsequent infestation leading to the death of the embryos. Our incubation methods have since been updated through the use of sealed containers for such large clutches, and adjusting the vermiculite: water ratio to 1:1 by weight. Strict application of this ratio has proved successful with eggs of other species, including *Brachylophis fasciatus and Lampropeltis triangulum hondurensis.*

We are confident that, with these improvements to the incubation technique, we will be successful with this species. This is highlighted by the fact that similar introduction procedures, etc. have been followed this year and we now have all three females gravid in holding boxes.

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THE BIOLOGY OF CAPTIVE SEA SNAKES

by John West
Aquarium Supervisor,
Taronga Zoo Aquarium
Mosman NSW 2088.

INTRODUCTION

Sea snakes have been exhibited at the Taronga Zoo Aquarium since the time of its opening in 1927. Improved understanding of the biology of several species of snakes and the evolution of successful husbandry techniques have produced longevity records of seven years and more for the maintenance of Laticauda species in captivity.

Approximately 51 species of sea snakes occur in the tropical and sub-tropical regions of the Indo-Pacific comprising 47 Hydrophiidae and 4 Laticaudidae (Heatwole, 1987).

This paper deals primarily with observations (in captivity) of the species *Laticauda schistorhynchus* (Brown Banded Sea Snake) and *Pelamis platurus* (Yellowbellied Sea Snake).

The species of sea snakes held at the Zoo have included:

Family Laticaudidae (Sea Kraits)
Laticauda laticaudata
Laticauda colubrina
Laticauda schistorhynchus

Family Hydrophiidae (True Sea Snakes)
Aipysurus laevis
Aipysurus duboisii
Acalyptophis peronii
Hydrophis elegans
Pelamis platurus

The sea snake exhibit at Taronga Zoo Aquarium is approximately 1.5m x 1m x1m deep, half filled with saltwater, heated to 25°C. The Aquarium usually operates on an open system but the exhibit includes a biological filter (sub-gravel plate) for emergency closed system operation. The behaviour of some species of emerging onto land is catered for by several large rocks which provide easy access to dry areas of the exhibit.

Lighting is supplied from 2 x 150 watt flood lamps and the exhibit has some access to indirect sunlight for short periods during the day.

OBSERVATIONS ON THE BROWN BANDED SEA SNAKE *LATICAUDA SCHISTORHYNCHUS*

In October 1983 three species of sea snakes of the Genus Laticauda were donated for display by Dr Harold Cogger and Dr Greg Mengden of The Australian Museum (0.0.1. *L.laticaudata*, 0.0.2. *L.schistorhynchus*, 0.0.4. *L.colubrina*). 0.0.4. more *L.schistorhynchus* were donated by Dr Cogger in December 1984. These specimens had been collected from various Pacific Islands for scientific identification.

At the time of writing (Oct.1990) 1 specimen of *L.schistorhynchus* had been in captivity at Taronga since Oct.1983 and 2 specimens since Dec.1984.

The Laticauda species are widely distributed from the islands of the Western Pacific through the Indo-Malaysian Archipelago and the Philippines to Japan and the Bay of Bengal. They are usually blue grey to creamish above with 25-70 black or brown cross-bands *(L.schistorhynchus* having brown bands), some or all of which completely encircle the body. Laticauda species grow to an average of 1m in length.

The venom of Laticauda (and *Pelamis platurus*) is highly toxic. All species of sea snake should be considered potentially dangerous. Specimens of Laticauda rarely attempt to bite even when freshly captured, however, handling of the animals is kept at a minimum. Anti-venom is kept on hand at all times.

Freshwater drinking habit of Laticauda sp.:

Sea snakes are totally aquatic, except for the Laticauda species. Laticaudids are often found out of water sometimes several kilometres from the sea. It was this land dwelling behaviour that prompted the introduction of a source of freshwater to the original holding facility (West & Boylan, 1989) and incorporated into the exhibit as a constant source of freshwater.

At the initial introduction of freshwater three species of Laticauda *(L.laticaudata, L.colubrina,* and *L.schistorhynchus)* began to drink from the freshwater container (500ml capacity). The quantity drunk by a 1.2m long *L.colubrina* was measured at 30mls (taking almost 12 minutes) and for a 60cm long *L.laticaudata* at 15mls over a 4 minute period. The long drinking behaviour and large quantities consumed may have been due to the snakes being dehydrated. Since the initial introduction of freshwater the snakes have been observed to drink regularly from the container.

The snakes are often found coiled up in the freshwater container prior to shedding their skin. Shedding frequency is generally every 3-4 weeks throughout the year.

Although sea snakes are reported to receive their freshwater requirements from prey and ingestion of some salt water (controlling their salt balance with special salt glands associated with the floor of the mouth), it is the author's hypothesis that opportunistic freshwater drinking behaviour for species other than the Laticaudids, may be possible.

Sea snakes, in general, would have the opportunity to come into contact with freshwater during heavy tropical rain periods. Freshwater can lay on top of the ocean for some period of time (several minutes to half an hour or more). It may be possible that sea snakes, other than Laticauda species, could come to the sea surface and ingest freshwater before it disperses.

The freshwater drinking behaviour for species other than the Laticaudids has not been observed by the author nor has it been reported in the literature.

Egg laying behaviour in *L.schistorhynchus:*

All sea snakes with the exception of the Genus Laticauda are live bearers (viviparous). Laticauda species come onto land to lay eggs (oviparous). The clutch sizes in the wild can range between 4-20 eggs. In captivity mating has been observed in August through to October during three separate years.

Fertile eggs were found in the exhibit on five occasions (June, October, November) over a three year period and only two eggs have been laid at any one time. The eggs ranged in size between 80-87mm long x 19-28mm dia. and weighed 29.5 - 39.5 grams. On all occasions they were found in the water. Although immediately transferred to the Reptile Department for incubation there was no further development, possibly due to the immersion period prior to the eggs being discovered.

A sandy area covered by a rock ledge was installed in the exhibit to encourage the snakes to lay the eggs under the ledge in moist conditions but so far this has not eventuated. Continued efforts will be made to breed this species in captivity.

Feeding behaviour in *L.schistorhynchus:*

L.schistorhynchus, at Taronga Zoo, feeds exclusively on a small fish called Whitebait *(Hyperlophus vittatus)* which is commercially available and grows to around 10cm in length. The snakes are fed three times a week with an average of 4 fish per snake per feed. Once a week

a 20% solution of a vitamin and mineral supplement (Avidrops used in aviculture) is injected into the gut of the food fish.

The snakes become very active at feed times and the food fish are scattered on the bottom of the exhibit. The snakes have been observed pushing the fish against the rocks with their body and proceed to push their head under their body coils and bite the fish. The fish is then manoeuvred around to the typical head first position and swallowed.

OBSERVATIONS ON THE YELLOWBELLIED SEA SNAKE *PELAMIS PLATURUS*

Pelamis platurus has the largest distribution of all sea snakes from the east coast of Africa throughout the Indo-Pacific Region northward to Japan, southward along the eastern coast of Australia and eastward reaching the western coast of the Americas (Kropach,1975). They are considered to have tropical and sub-tropical distribution.

P.platurus is not normally found in deeper waters, but mostly in the shallower waters off the continental shelves or around reef systems (Heatwole,1987). The movement of *P.platurus* is determined by surface currents and large numbers are often found in extensive congregations or large slicks extending over several kilometres.

The Yellowbellied Sea Snake is most commonly encountered stranded on beaches along the eastern coast of Australia during April to October each year (usually after heavy storm activities). *P.platurus* is usually unable to move around on land and will certainly die from dehydration or predatory birds if left on the beach.

Often these stranded specimens are brought into the Zoo for rehabilitation and in some cases they are successfully released back into the wild (far out to sea) by the Royal Australian Navy.

The most critical period for their survival is the first 24 hours. 80% of the Yellowbellied Sea Snakes do not survive the first day due to their distressed state or the extent of their injuries.

Longevity for *P.platurus* at Taronga Zoo ranges up to 9 months when two specimens which had been rehabilitated were released off the NSW Coast by the Navy. Longevity recorded in North American collections list this species at 2 years and 1 month (Bowler, 1977).

Feeding behaviour of *P.platurus* in captivity:

P.platurus relies on deception of the prey at the surface and on a slow and deliberate approach to capture prey. As schools of small fish aggregate near the snake, fish feeding occurs, usually with a rapid sideways lunge as the prey moves within reach.

Although known to eat a variety of surface fish in the wild they seem reluctant to feed in captivity with only a small number eventually able to catch their own live food.

A feeding technique was developed where a fresh live fish was held in a long pair of forceps and moved along the body of the snake towards the head. Unfortunately, in most cases, the snakes had to be force fed initially, until they gained sufficient condition to enable them to eat unaided.

ACKNOWLEDGEMENTS

I would like to thank the past and present Aquarium staff for their diligent recording of feeding and drinking behaviour of the Sea Snakes at Taronga. I would like to thank Mr Terry Boylan for his assistance with feeding techniques and his review of this paper, the Director of Taronga Zoo for his review and comments and the Zoological Parks Board of NSW for allowing me to publish these observations.

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OSTEODYSTROPHY IN AN ASIAN AGAMID *(HYDROSAURUS PUSTULATUS)*

Jon Birkett, Herpetofauna Department and
Helen McCracken, BVSc., BSc (Vet)., MVS.,
Veterinary Department, Royal Melbourne Zoo,
P.O. Box 74, Parkville, Victoria 3052, Australia.

INTRODUCTION

A group of four juvenile Philippine Sail-tailed Water Dragons *(Hydrosaurus pustulatus)* was received from Dallas Zoo in November, 1988.

The physical morphology of the species reflects its aquatic existence in the Philippines where it frequents the wooded banks of rivers and streams (Gonzales, 1974). The toes of the hind feet possess permanently extended toe flanges running the full length of each toe. Its tail is very strongly laterally compressed with the adornment of a high median dorsal crest at its base, (Banks, 1989) which is higher in males than in females.

This large Old World Agamid of 1.1m total length is listed as a Vulnerable species, (I.U.C.N., 1988) as are many species of fauna in the Philippines. Hence, there is a need to establish long-term self-sustaining populations in captivity with the fundamental objective of ensuring long term self-sustaining populations in their native environment.

The Keepers in the Herpetofauna Department of Melbourne Zoo collectively have many years experience maintaining, breeding and raising agamid lizards under artificial conditions. Nevertheless, the problems encountered in raising this group of lizards have focused our attention on the need for even greater observational skills and awareness of the environment and behaviour of captive agamids.

ACCOMMODATION AND NUTRITION

Upon arrival from Dallas Zoo, the lizards had to be housed in an insect proof enclosure for 110 days for quarantine against equine encephalitis virus. Due to restricted off-limit accommodation, the group was housed together in a glass-fronted timber enclosure, (1200 x 600 x 650mm) with floor heating and a substrate of commercially available coarse aquarium gravel.

It is commonly understood by herpetoculturalists and herpetologists that ultraviolet radiation is an essential element for healthy bone development in agamid lizards. Exposure to natural solar radiation or artificial ultraviolet radiation is required for the production of Vitamin D_3 in the skin of reptiles (Townsend & Cole, 1985). This vitamin is essential to the body's ability to absorb calcium from the diet, and calcium, in turn, is needed to maintain strong, fracture-resistant bones (Behler, unpublished.). It has been found that, in order for vitamin D_3 synthesis to occur, lizards must be exposed to medium wavelength U.V. light (UV-B) between 285-315nm. Maximum vitamin D_3 production occurs at 297-305nm (Ullrey *et al.*, 1986).

In the past (from 1980-1987), Duro-test Vita-Lite fluorescent tubes were used in our collection to provide U.V. light. These lights are designed to simulate natural sunlight in emitting a full spectrum of light wavelengths, including UV-B. Recent studies on these lights, however, have demonstrated that the UV-B wavelengths (290-320nm) represent only a very small percentage of their output, and furthermore that the UV-B irradience drops to 85% of initial ouput after 2000 hours of use (approx. 6 months if illuminated 12 hours per day); to 79% after 4000 hours; and to 72% after 9000 hours (Townsend and Cole, 1985). We have seen evidence of this attrition of useful light in our use of Vita-Lites. In 1980, when our lights were new, young agamids were raised successfully, but in the following year when the lights were 12-14 months old, we began to encounter serious skeletal abnormalities in our young agamids.

The U.V. light source now favoured over Vita-Lite is the Blacklight (BL type) which emits approximately ten fold more U.V. light in the 290-320nm range than the Vita-Lite (Townsend and Cole, 1985). Animals must be within 400 mm of these lights in order to benefit from the radiation, and may be so close without any risk of damage to eyes or skin (Behler, unpubl.).

Therefore a 40 watt fluorescent Blacklight (BL type) was placed on top of the enclosure of the new *H. pustulatus*. As the light was 650 mm above the substrate, several branches were strategically placed to enable the lizards to position themselves within 400mm of the Blacklight.

The diet our lizards were offered did not differ from the diet fed to all agamids in the collection. It consisted of a soft fruit and vegetable mixture with the addition of approximately 10% total volume of softened dry dog food pellets, or diced boiled egg. A calcium powder supplement was also liberally mixed into every preparation, which was fed three times a week. In addition to this prepared diet, crickets dusted with calcium powder, commercially raised mealworms and pink mice were offered approximately twice per week.

Aggression between the four individuals occurred two weeks after arrival, with some tail loss suffered by three lizards. This behaviour forced us to make major changes in accommodating our off-limit animals, to allow each to be housed individually. Each lizard was given identical housing in the same box type as described earlier. However, the two boxes used were divided into four, by sliding a wooden panel into each box, dividing it into two equally sized compartments (600 x 600 x 650mm).

In April, 1989, five months after the lizards arrived, they had completed their quarantine period and were transferred to a large display enclosure (2.0 x 2.5 x 1.8m). The enclosure was heavily planted to obscure the lizards view of each other and hopefully prevent aggressive behaviour. Also provided, were a large number of branches and small tree trunks for climbing and to gain access to the U.V. light and heat lamps above the enclosure.

As we expected, but had hoped would not occur in such a large, well-vegetated enclosure, two lizards in the group soon became dominated by the two more aggressive individuals. These were returned to their off-limit enclosures only five days after introduction. This type of dominance-subordination behaviour among captive *H.pustulatus* is well documented (Gonzales, 1974). Competitive aggression between individuals was most evident at feeding sites; and although several sites were provided, the dominant lizards would vanquish the subordinate specimens. Shortly after this separation, the subordinate animals were returned to display in an effort to get the animals together as a group.

METABOLIC BONE DISEASE

In July, 1989, nearly seven months after the lizards' arrival at Melbourne Zoo, one individual (Lizard #4) on public display was observed to have difficulty moving its hind-limbs. Upon examination, the animal's thighs were found to be extremely swollen and firm on palpation. Whole body radiographs were taken to investigate the problem. These revealed a poorly mineralised skeleton and very thin bone cortices. In addition there were displaced fractures of both femurs, and angulation of the shafts of left radius and ulna. A diagnosis was made of osteodystrophy.

Osteodystrophy in lizards may be caused by either a dietary calcium-phosphorus imbalance or a vitamin D_3 deficiency (due to inadequate exposure to U.V. light), or a combination of the two (Frye, 1981). With calcium and vitamin D_3 deficiencies, calcium is eventually reabsorbed from the skeleton in order to maintain blood calcium levels above critical level. As a result the bone cortices become very thin, and the bones are soft and bend and break easily. Another change which may occur is the deposition of a fibrocartilage matrix around the weakened bones. Physical stresses exerted on the bones during climbing and running stimulate the periosteum to reinforce the weakened bones by the formation of cocentric layers of osteoid,

cartilage and immature fibrous connective tissue (fibrocartilage) which are laid down around the bone shaft. As a result, affected animals have markedly firm, swollen limbs (as was seen in Lizard #4).

In this case, examination of the lizard's diet and U.V. light exposure led us to conclude that the latter was the major problem. Using recorded values for the Ca and P content of a variety of food stuffs (Cooper and Jackson, 1981), the Ca : P ratio of the diet was roughly calculated as 1.2 : 1 which is considered the ideal ratio (Cooper and Jackson, 1981). Furthermore, this diet has been used previously at Melbourne Zoo to successfully raise many species of agamid. Close examination of the U.V. light situation, however, led us to identify that as the major cause of osteodystrophy. In the display enclosure several new blacklights were mounted and several new basking sites (branches) were provided within 400mm of the lights. We assumed, therefore that we had fulfilled the lizards' U.V. radiation requirements. On closely evaluating the situation however, we came to realise that the dominance-subordinance relationship between the individual *H. pustulosus* may have, in fact, dictated the quantity of U.V. radiation each lizard received. When more than one animal were housed together, the dominant lizard would command the best vantage spot under the blacklight, preventing the others from getting close enough to be adequately irradiated. Of the four lizards, two were clearly subordinate, and therefore probably deprived of adequate U.V. light exposure. It seems likely that the other two animals, having only recently been introduced to each other, were challenging each other for the dominancy and hence the favoured basking spot. It is possible that because of this interaction, neither of those animals received sufficient U.V. irradiation. The exact identity of the individuals at different hierarchial levels was not determined because when observed by keepers through the viewing glass, they became quite frantic and ceased their normal behaviour.

Given these conclusions about the lizards' U.V. light exposure, it was decided to radiograph the remaining three lizards, as it was possible that they were similarly affected although they had not displayed any clinical signs. All were found to have varying degrees of osteodystrophy, ranging from only moderate skeletal decalcification in two animals, one of which also had a digital fracture, to more advanced skeletal mineralisaton with tibial and digital fractures in the third - (Lizard #1). Given these findings, it seems likely that Lizard #1 and #4 were the subordinate animals most deprived of light.

IMPROVED HOUSING AND TREATMENT

Upon recognition and diagnosis of this problem, the most seriously affected animals, Lizards #1 and #4, were immediately removed from the display enclosure and were housed in small off-limit boxes (600 x 600 x 400mm) for complete cage rest. They were not provided with any climbing branches in order to ensure minimal limb use. The only enclosure furnishings provided were an artificial turf substrate and a water dish. A Blacklight (BL type) was positioned above the enclosure, 400mm from the floor. Cage rest was elected above external or internal fixation as the only feasible way of managing the long bone fractures. In most cases, displaced fractures of femur and tibia would be reduced and stabilised using either external fixation (a cast or splint) or internal fixation (a pin or plate and screws). In these lizards, external fixation was considered a risk as the weight of a cast and the distress it may have caused the animals may have resulted in more fractures of the soft skeletons. Internal fixation would not have been possible because the placement of pins and screws in the soft bone would most likely have caused further fractures, and the encirclement of the femurs of lizard #4 with fibrocartilage would have made placement of the fixation devices very difficult. As the successful healing of bone depends largely on effective stabilisation of fractures, the femurs and tibia of these lizards were given a poor prognosis, as it was believed that cage rest, although it was the only choice, would not give sufficient stabilisation. It seemed likely that the fractures would not heal, and would become "non-unions".

In addition to cage rest, Lizards #1 and #4 were treated with injectable 10% calcium gluconate, given subcutaneously at a dose of 1ml/kg, every second day for three weeks.

The two less severely affected lizards were left in the display enclosure and watched closely to ensure that both were making adequate use of the Blacklights. They were also treated with injectable calcium for three weeks, as described above.

The lizards' conditions were monitored by taking whole body radiographs every 6-8 weeks. A handling technique was developed which greatly facilitated positioning of the animals for radiography. The lizards were either held in the hand or positioned on the x-ray cassette, and their tympani stroked gently and repetitively for approximately 30 seconds. This would cause them to enter a temporary "trance" , allowing them to be gently manipulated into the desired position and then radiographed lying still on the cassette without requiring any physical restraint. They would come out of the trance after 30 to 60 seconds so we were always on the alert for a suddenly re-activated lizard.

The radiographs taken 6 weeks after the commencement of treatment were very encouraging. There was no perceptible increase in the degree of calcification of the skeletons, but fracture healing had commenced. Extensive callus production (new bone formed around a fracture site to rejoin the bone) had occurred giving all the fractured bones structural rigidity. Lizard #4 had developed new fractures (of left humerus, both radius and ulnas and several digits) since the commencement of treatment, but these fractures had also commenced healing. Six weeks later, further improvement was evident. In all but Lizard #4, the degree of skeletal calcification had increased and the bone cortices had thickened. In all fractures, the fracture line had been completely bridged with new bone and remodelling had commenced. Remodelling is the last stage of fracture healing where the bone, which in these cases had healed together with considerable degrees of angulation, gradually reassumes its original linearity, and the callus is gradually redistributed so that eventually the bone's conformation is very similar to its original pre-fracture form. Eight weeks later (20 weeks after the problem was first recognised), there was a clear increase in skeletal calcification and thickness of bone cortices in Lizard #4. All fractures had further remodelled. At this stage, Lizards #1 and #4 had grown considerably since the commencement of treatment, were extremely well muscled, and moved around very strongly.The thigh diameter of #4 had not reduced, and it is thought that the fibrocartilage responsible will not resolve, resulting in permanent swelling there. Branches were once again provided to these lizards to permit them to resume climbing.

Further radiographs after this time indicated further bone remodelling, until at approximately 30 weeks, the sites of the major long bone fractures were very similar to their pre-fracture conformation.

In July, 1990, the Herpetofauna Department received the first of a number of off-limit holding complexes for arboreal lizards. The new tiered facilities were designed to accommodate almost 70% more animals in the same available space. In achieving space efficiency in a limited area, it enables us to house animals individually if necessary and address interspecific differences in husbandry requirements.

All four *H. pustulatus* are currently individually housed in the new arboreal complex. The greatest advantage incorporated into the design is the provision of time-controlled twin light fittings over each vivarium. Each fitting contains one white fluorescent tube and one U.V. blacklight, positioned on top of the enclosure 350mm above an easily accessible timber shelf.

The new arboreal complex has effectively eliminated competition between individuals for essential environmental elements. Nevertheless, acute observational awareness of every animal's daily movements and habits must be maintained by keepers to ensure each individual receives maximum benefit from the environmental elements provided for a healthy life.

CONCLUSION

The causes of osteodystrophy and the effective use of artificial U.V. light sources for herpetofauna maintained indoors is well documented in the literature. Skeletal abnormalities however, can still occur despite having provided correct environmental and dietary requirements. If an animal is not using the provided U.V. light source, particularly juvenile agamids, it will certainly suffer skeletal abnormalities. It is, therefore, vitally important that skilled observational monitoring of a lizard's use of its light source is maintained to ensure healthy growth.

These cases were very interesting in that remarkable bone healing was seen in displaced fractures in badly compromised bone, without the use of any bone stabilisation devices. It was interesting to see that complete cage rest, parenteral calcium supplementation and provision of adequate U.V. light exposure was sufficient to effect normal bone healing.

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A MODIFIED APPROACH TO THE ANTIMICROBIAL AND SUPPORTIVE THERAPY OF REPTILES SUFFERING FROM NECROTIC STOMATITIS

by Bruce Munday
1/85 Riverside Drive
Launceston TAS 7250

ABSTRACT

Positive results obtained by establishing treatment on the basis that the aetiology of Necrotic Stomatitis in Reptiles may initially be a gram-negative anaerobic infection, as in Vincent's ulcerative gingivitis in Humans and that the commonly encountered Reptilian Aerobic gram-negative flora are participating as secondary invaders.

INTRODUCTION

Despite the recognised importance of correct husbandry and nutrition in the prevention of this disease among captive reptiles, those involved in reptilian therapeutics will, nonetheless, be presented with cases of varying severity, requiring treatment.

The effectiveness and degree of safety for the patient, has been considered by the author, with the following objectives:

1. To compare aspects in the progression of the syndrome, suggesting possible predisposing factors common to both Reptiles and Humans.

2. To extrapolate any similarities in the context of current drug therapy for Reptiles, with a view to adapting aspects of drug regimes used in humans, if potential benefits are indicated.

3. To test the effectiveness in clinical use and to establish initial guidelines for the most likely beneficial substances.

DISCUSSION

Gingival tissue is highly vascularised and subject to incidental trauma; factors that decrease the perfusion of blood to such a structure predispose it to attack by bacteria. A contributing factor of this nature may be seen as an increased fragility of capillaries, consistent with suboptimal availability of ascorbic acid, causing defective formation of colloidal intercellular substances. It would not seem unreasonable to apply these considerations equally to the Reptilian gingiva, just as they already are, in the Human model.

The relationship between the dental structures and gingival tissues provides an environment with limited contact with the atmosphere. This is particularly evident in Boid snakes, where scores of prominent teeth are deeply sheathed in the extensively mobile gingiva. Factors affecting the viability of tissues within such an environment, provide a situation where the necrotic process is affected by the bacteria most suited to these conditions.

In Humans, it is the gram-negative obligate anaerobes - Bacteroides and Fusobacterium spp that are commonly isolated at the onset of Necrotic stomatitis. As *obligate anaerobes*, they are, so to speak, "obliged", to pursue their existence in the absence of oxygen, and such special *anaerobic* conditions must be applied to culture them in the laboratory.

In Reptiles, the isolates from necrotic gingival ulcers, are usually cited as being Aeromonas hydrophilia and Pseudomonas aeruginosa. Of particular comparative interest, is Aeromonas hydrophilia, in that, it is a *facultative anaerobe* - being able to tolerate both normal *aerobic and anaerobic* atmospheres. It may therefore, be cultured in the same manner as the strictly *aerobic,* Pseudomonas aeruginosa, using the standard culturing systems in a normal atmosphere.

It would seem a strong possibility that, given the favourable conditions for *anaerobic* bacteria in the gingiva of Reptiles, especially, Boid snakes; the isolates of Aeromonas hydrophilia may be part of a *mixed anaerobic* infection and that the *obligate anaerobes,* like Bacteroides and Fusobacterium spp are escaping detection when standard culturing techniques are used.

The role of important gram-negative *aerobic* Reptilian pathogens like Pseudomonas aeruginosa, in this scenario, is as opportunistic secondary invaders - whereas, in the Human syndrome, gram-positive *aerobic* pathogens such as the Streptococci become involved as the necrotic process advances.

DRUG THERAPY

If the presence of *obligate anaerobes* such as Bacteroides and Fusobacterium spp. are suspected as active participants or instigators in a case of Necrotic stomatitis, then the initial selection of antimicrobials may include a suitable agent directed towards them. This contingency should ideally be confirmed by appropriate culturing of samples.

Some antibiotics already recommended for use in treating the syndrome in Reptiles at the mild-to-moderately-severe stage, have some activity against these organisms viz. Choramphenicol and Tetracyclines.

Their action, by inhibiting the multiplication of susceptible strains, is *bacteriostatic.* Although they have, in the past, been widely used in Human medicine, this has declined somewhat; partially due to the increasing emergence of resistant strains of bacteria, and/or, in the case of *anaerobic* infections, the development of more effective agents that produce a *bacteriocidal* "killing effect", rather than a *bacteriostatic* one.

The current drug therapy for Acute ulcerative gingivitis in Humans, frequently includes Metronidazole. This same drug is widely used in Reptiles, to treat some protozoal infections. It is well tolerated by both Reptiles and Humans.

In Humans, Metronidazole has well established *bacteriocidal* activity in gram-negative anaerobic infections. Furthermore, the development of resistance in sensitive species is very rare. Metronidazole is widely distributed throughout the body, as indicated by its successful use in the treatment of septicaemia, brain abscess, necrotising pneumonia, osteomyelitis, pelvic abscess and so on.

There would seem sufficient grounds to consider Metronidazole as part of the immediate drug therapy, for Necrotic stomatitis in Reptiles, while awaiting results of bacterial culturing, which should include cultures grown under anaerobic conditions.

Dose rate, by oral or parenteral route = 150mg/kg once daily for five (5) days.

Where bacterial cultures indicate the active role of Pseudomonas aeruginosa, as well as *mixed anaerobes,* it should be borne in mind that some antibiotics, like amino-glycosids, which may be effective against this organism, are not active against *obligate anaerobes.*

The author has explored the potential of an additional antimicrobial substance, not previously used in Reptiles, as far as he is aware, which is active against Pseudomonas aeruginosa and other aerobic gram-negative bacteria. It is one of the fluoroquinolones - ciprofloxacin (ciproxin [R]) - a synthetic antimicrobial, unrelated to the other major antibiotic groups.

It offers the following advantages:

being rapidly absorbed from the gastro-intestinal tract, following oral dosing - thus avoiding the stress of intramuscular injection, used for Chephalosporins and Antipseudomonal Penicillans, particularly in animals of low or reduced muscle mass.

not exhibiting the nephrotoxic potential of aminoglycosids, nor potentiating neromuscular blockage when used on its own, or concurrently with an anaesthetic.

Cross resistance with other antibacterial agents appears to be rare, as resistance is not transferable on plasmids, thus, making it an excellent first-line treatment for serious infections.

The author has successfully used ciprofloxacin for gram-negative aerobic infections of the gastro-intestinal tract, respiratory tract, soft tissue and bone, and also, in conjunction with Metronidazole, for *mixed aerobic/anaerobic* infections, including acute *Necrotic Stomatitis.*

Dose rate = oral - 10mg/kg first two doses, twelve hours apart; then continue for seven to ten (7-10) days, once daily. It may be mixed with oral doses of Metronidazole and given at the same time.

SUPPORTIVE THERAPY

The rationale for supplementation of Absorbic acid (vit C) in Reptiles, as an adjunct for prevention of Necrotic stomatitis, based on the maintenance of capillary structure and therefore, blood perfusion to the gingival tissues as outlined previously, would seem as applicable in Reptiles as it is in Humans.

Given the potential benefits combined with the safety of use, due to its water-solubility -allowing easy excretion, Ascorbic acid should be routinely added to Reptilian diets.

The difficulty of assessing the degree of extra demand for this vitamin that inapparent stress may place on captive Reptiles, has suggested to the author that at least in snakes, and particularly, Boids; ascorbic acid, in the form of Calcium ascorbate dihydrate - to avoid undue increase in gastric acidity - should be added to each meal.

The author uses 10-50mg for animals up to 100g BW, increased by 50mg per 100g, up to 1kg, beyond which, 1000mg remains the standard supplement of Calcium ascorbate, in powdered form, dusted onto the food item, or dissolved in water and injected into the food. The author has not encountered any adverse effects using this Vitamin C regime.

Various authors recommend Vit.C supplementation while treating *Necrotic stomatitis*, usually as an injection of Ascorbic acid 5-30mg. If the animal is receiving medication or nutrition by oral route, calcium ascorbate powder could be added, if compatible to the other substances. The author favours between 10-200mg, if given daily, until normal feeding is resumed, at which time, the system used before, should be adopted to continue to provide optimal rather than just adequate levels of this vitamin.

During any antibiotic therapy, the possibility of fungal overgrowth should be considered. The author, prophylactically administers an oral anti-mycotic - Nystatin, 20,000 units/kg daily, during treatment, then, after treatment has finished, laces the next two or three meals with 50 million or so Lactobacillus acidophilus organisms per kg/BW, to provide some "friendly flora" for recolonising the gut.

Lactobacillus is available as freeze-dried powder, which should be kept regrigerated. The author has found it perfectly suitable for Reptiles. Both it, and the antimycotic are adaptations of standard Human therapeutics.

Nutrition can often prove difficult when snakes (in particular, with *Necrotic stomatitis)*, are presented for treatment in an anorectic state, or which become anorectic after treatment.

If the animal is not holding good body condition the author prefers, where possible, to correct this, using liquid nutrition as a complete dietary replacement. The product used is "Ensure (R)" powder, for reconstitution - available from most chemists. It contains complete nutrition with about the same percentage of protein - (15%) as supplied by whole mice. Thus, a snake whose meal would consist of a 25g mouse, would receive 25ml of "Ensure" solution. As well as avoiding the stress of force-feeding a prey-item, the use of "Ensure (R)" does not require a tube any larger in diameter than that issued with a standard infusion kit - an ideal material.

Tube feeding diets consisting of various slurries may require larger diameter tubes and are more stressful to introduce.

A Copper Head *(Austrelaps superbus)* - low land type was maintained for over six months on a diet of "Ensure", while recovering from *Necrotic stomatitis,* complicated by *Necrotic enteritis,* with emaciation. During that time, it increased its body weight by 100% and made a complete recovery.

CONCLUSION

The initial removal of exudates and debridement of necrotic tissue (already covered by other authors), is paramount to effective treatment of acute *Necrotic stomatitis.*

The additional measures outlined in this paper, have been formulated to supplement existing procedures and to improve the prognoses. It is hoped that this paper will stimulate laboratory investigations such as the one proposed by Taronga Zoo to study the role of bacteria (anaerobic and aerobic) and fungi in *Necrotic stomatitis* in snakes.

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This issue of Herpetofauna contains some of the papers delivered at the Australasian Conference on Care and Captive Breeding of Reptiles and Amphibians, held 29 September - 1st October 1990. This conference was organised by the Australian Herpetological Society to celebrate its 40th anniversary. Other papers delivered at the conference will be published in the next issue of Herpetofauna.

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Telephone: (02) 906 2937